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(19) (CA) **APPLICATION FOR CANADIAN PATENT** (12)

(54) Method for the Manufacture of a Porous, Mineral Lightweight Insulating Board

(72) Dennert, Veit - Germany (Federal Republic of) ;
Dennert, Frank - Germany (Federal Republic of) ;

(71) Veit Dennert K.G. Baustoffbetriebe - Germany (Federal Republic of) ;

(30) (DE) P 44 08 088.3 1994/03/10

(57) 14 Claims

ABSTRACT OF THE DISCLOSURE

A method for the manufacture of a porous, mineral lightweight insulating board comprises the following steps:
producing a binder slurry from cement, quartz powder, lime hydrate and water, preferably in a colloid mixer;
producing a foam in a foam production unit from water, compressed air and an air entrainer;
mixing the binder slurry and the foam to form a porous concrete substance;
homogenizing the porous concrete substance by means of a continuous mixer;
discharging the porous concrete substance into a mold for the formation of a molded cake for the lightweight insulating board;
initially stiffening the molded cake preferably in a ripening chamber;
cutting the molded cake into individual lightweight insulating boards; and
curing the lightweight insulating boards in an autoclave.

METHOD FOR THE MANUFACTURE OF A POROUS, MINERAL LIGHTWEIGHT INSULATING BOARD

BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

The invention relates to a method for the manufacture of a porous, mineral lightweight insulating board, as it may for instance be used to replace polystyrene boards or mineral boards as thermal building protection.

BACKGROUND ART

It is known from the prior art to manufacture so-called gas or porous concrete blocks, which have a density of some 100 kg/m^3. Owing to their porous structure, these porous concrete blocks have excellent heat insulating properties.

Roughly outlined, these porous concrete blocks are made from a binder slurry (with lime or cement as a binder), which is expanded by the addition of an expanding agent on the basis of an aluminum compound. This way of manufacture involves the problem that, as a rule, a density gradient from the bottom upwards as well as microcracks in the block structure may occur as a result of the expansion. Moreover, the metered addition of the aluminum compound is very critical. The manufacture of substances of extremely strong porosity having apparent densities of less than 200 kg/m^3 is almost impossible.

Because of the above-mentioned circumstances it is not possible in practice with the methods used for the manufacture of porous concrete blocks to manufacture mineral leight-weight insulating boards that must have an apparent density of 100 to 200 kg/m^3 and less in order to possess heat insulating properties comparable to polystyrene boards.

Tests have shown that in the case of a correspondingly increased expansion of the binder slurry, the method suitable for the manufacture of porous concrete blocks results in lightweight insulating boards not having sufficient structural stability in the first place.

DE 41 18 537 C1 discloses a method for the manufacture of cement foam, by which, however, only foam densities of 250 to 400 kg/m^3 are attainable. As discussed, these foam densities are too high to achieve the desired heat insulating properties in the insulating board made from such a cement foam.

Further, DE 42 16 204 A1 discloses a porous, mineral lightweight insulating board, which substantially consists of calcium silicate hydrate, silica and possibly a porous loading agent and which is prepared with such a pore count and distribution as to have a weight per unit volume of less than 220 kg/m^3 and a coefficient of thermal conduction below 0.050 W/mK. As regards the components of this heat insulating board, the calcium silicate hydrate component is explained to be preferably due to the presence of slaked lime, silica and water in the basic manufacturing material. Alternatively, a portion of burnt lime may be employed, which is hydrated by water absorption during the manufacture. Preferably, the silicon dioxide component of the heat insulating board according to the invention substantially consists of quartz powder and/or amorphous silicic acid.

As regards the formation of pores, it can be taken from DE 42 16 204 A1 that water contained in the wet manufacturing material is evaporated during the curing or, respectively, that pores are formed with the aid of a pore forming agent in the manufacturing material and are then present in the finished heat insulation boards. Preferred pore forming agents are tensides, aluminum powder or peroxo compounds. The problems mentioned at the outset should arise at least with the use of aluminum powder. Moreover, tests of Applicant have shown that the application of generally known manufacturing methods for heat insulating boards according to

DE 42 16 204 A1 gives rise to practical problems of obtaining heat insulating boards of the indicated weight per unit volume and heat conductivity which exhibit the structural stability necessary for reliable use at site. Any approaches to the solution of these problems cannot be taken from DE 42 16 204 A1.

Another problem with the heat insulating boards according to this document resides in the water absorption of these heat insulating boards during transport, storing and when used in building. It can be taken from the document that the surface of the heat insulating boards is provided with a water-repellent agent applied by brushing or spraying. But there is the fundamental requirement that heat insulating boards fixed to the wall of a building must be floated prior to the application of a layer of cast, thin as a rule, on their surface, so as to compensate any differences in height where the boards join. During this floating operation, for instance by means of a so-called float, the top layer of the heat insulating boards and thus the water-repellent agent on the surface are removed, so that the board can take up humidity where it has been floated. This means that the boards take water from the layer of cast subsequently applied, which results in inhomogeneities within the layer of cast and in a humidification of the board, deteriorating the heat insulating capacity. Humidification will also impair the frost resistance of the boards.

The older patent application P 43 27 074.3 deals with a method for the manufacture of a mineral lightweight insulating board, in which a binder slurry of the conventional components of water, quartz powder, lime hydrate and cement is prepared in a so-called paddle agitator and into which a foam produced in a foam production unit is subsequently stirred. The porous concrete thus produced allowed the manufacture of mineral lightweight insulating boards of a density ranging from 100 to 200 kg/m^3 and a specific thermal conductivity of approximately 0.05, and of improved structural stability and homogeneity to a limited degree, but these boards still did not exhibit the properties, needed for the reliable use in

practice, as to strength, heat insulating power and water-repellent behavior.

SUMMARY OF THE INVENTION

It is accordingly the object of the invention to specify a method for the manufacture of a porous, mineral lightweight insulating board, which will comply with the practical requirements in building as a result of its high degree, conditioned by the manufacture, of strength and heat insulating properties.

This object is solved by a method comprising the following steps: producing a binder slurry from cement, quartz powder, lime hydrate and water, preferably in a colloid mixer; producing a foam in a foam production unit from water, compressed air and an air entrainer; mixing the binder slurry and the foam to form a porous concrete substance; homogenizing the porous concrete substance by means of a continuous mixer; discharging the porous concrete substance into a mold for the formation of a molded cake for the lightweight insulating board; initially stiffening the molded cake preferably in a ripening chamber; cutting the molded cake into individual lightweight insulating boards; and curing the lightweight insulating boards in an autoclave. The outstanding features of the invention are considered to be the individual production of a binder slurry and a foam, the mixing of these two components to form a porous concrete substance, and in particular the latter's homogenizing by means of a continuous mixer. Test have shown that the use of this process sequence serves to form an especially homogeneous porous concrete of fine air pores, which will give an especially solid and high-temperature insulating board after the autoclaving. The reason for this is considered to be the particularly gentle homogenizing in the continuous mixer used, which preferably is a so-called static mixer as used for many applications in chemical industry. Such continuous or static mixers are characterized by the fact that there are no rotating parts, by their momentum exercising forces on the porous concrete that might lead to a destruction

of the pores. Rather, in the continuous or static mixer, the homogenizing is caused by static guiding elements leading to turbulences in the porous concrete when it is pumped through. Obviously, this constitutes an especially gentle way of homogenizing, resulting in excellent properties in the lightweight insulating boards thereby produced.

The preferred mixing of the binder slurry and the foam with the aid of a mixer tube branched in the form of a Y is technically particularly simple on the one hand, but on the other hand it results in a preliminary mixing of the porous concrete components sufficient for the further homogenizing in the continuous or static mixer.

Further preferred embodiments of the method according to the invention relate to a finishing treatment of the autoclaved lightweight insulating boards, according to which the latter are provided with a water-repellent and/or hardening impregnation. This impregnation is characterized by the fact that the depositing of the impregnation takes place in such a way that, proceeding from the board surface, the impregnation extends inwardly by a certain depth of penetration - at least 1.5 cm are considered to be advantageous. Different effects are achieved with the aid of this preferred impregnation, which are directed to the lightweight insulating board itself:

- Because of the penetrating depth of the impregnation, the lightweight insulating boards can be floated on their surface without the water-repellent qualities of the impregnation being impaired. Consequently, the cast layer to be applied after the mounting of the lightweight insulating boards to the wall of a building meets with water-repellent properties constant over the surface of the boards, so that no irregular water absorption from the cast layer by the insulating board can take place and the frost resistance will not be impaired.

- Because of the impregnation layers on all its surfaces, the insulating board is excellently protected against penetrating water so that even

when the boards are stored in the open at site, humidification is not to be expected. The lightweight insulating boards according to the invention do not make any special demands of protected storing.

- Because of the hardening of their surfaces, the boards are very well protected against being impressed so that no special care must be taken when the boards are handled at site.

- Because of the impregnation of the board all over, rigid layers including between them a layer of reduced strength form in the vicinity of board faces turned away from each other. The lightweight insulating board has a structural design similar to that of a multilayer composite board. In the manner known from the latter, this results in a substantial increase in the strength of the board, in particular the bending tensile strength increasing.

- Because of the hardening of a surface zone of the board, plugs can be anchored especially reliably in the board.

- Because of the coloring of the impregnating layer for instance by iron oxide pigment, optimal controllability of the boards is ensured to the effect that board zones not impregnated, which appear during the floating for the board joints to be levelled or when the boards are cut to size for instance in the case of window bays, are recognized immediately and can then be impregnated subsequently.

Fundamentally, the impregnating compound is applicable by overpressure or partial vacuum for soaking into the board. In particular, the overpressure method is known from the pressure impregnation of wooden components. When applied to the lightweight insulating boards according to the invention, the pressure impregnation may be applicable if certain limits of maximum pressure and of the rapidity, by which pressure actuation and relief will take place, are observed, but it is not without problems. For instance, the impregnating compound soaked into the boards

by the application of pressure in a dip tank may be expelled again during pressure relief by re-expansion of the air in the pores inside the boards, so that the impregnation leaves much to be desired. Also, in particular in the case of too rapid a pressure relief, the boards tend to be destroyed like in an explosion, because the pores of the boards have a strong tendency towards expansion in the case of pressure relief. Last but not least, the apparatus requirements for overpressure impregnation are very complicated, because overpressure values of several bars must be dominated.

By reason of the above described circumstances, partial vacuum impregnating is to be preferred, the boards being impregnated in a manner gentle to the structure. More detailed explanations of this will become apparent from the exemplary embodiment, to which reference is made to avoid unnecessary repetition.

According to further embodiments of the invention, additional silicon dioxide carriers or, respectively, additional fiber glass may be mixed into the binder slurry. The additional silicon dioxide carriers may for instance be so-called "micro-silica" particles as they are commercially available as concrete admixtures. The fiber glass, which may optionally be mixed in for further increasing the strength of the insulating board, is alkali resistant and has a preferred fiber length ranging between 6 mm and 12 mm.

Further features, details and advantages of the invention will become apparent from the ensuing description of exemplary embodiments of the method according to the invention as well as the insulating board according to the invention, taken in conjunction with the drawing.

BRIEF DESCRIPTION OF THE DRAWING

Fig. 1 is a diagrammatic partial illustration of an installation using the manufacturing method according to the invention, and

Fig. 2 is a diagrammatic section through a lightweight insulating board according to the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to Fig. 1, the production of the porous concrete for the lightweight insulating board is explained first. A binder slurry of cement, quartz powder, lime hydrate and water is produced in a conventional colloid mixer, which is for instance provided with a paddle agitator. Being supplied from corresponding silos 2, 3, 4 via conveying means (not shown), such as feed screws, the solid components, while being weighed, can be automatically added to the colloid mixer 1 together with a corresponding quantity of hot water (of a temperature of approximately 40 to 50°C). Additionally, fiber glass and/or special silicon dioxide carriers can be mixed in. The following basic recipe can be used for the binder slurry:

30 kg cement
15 kg lime hydrate
50 kg quartz powder
2 kg alkali-resistant fiber glass (fiber length ranging from 6 mm to 12 mm)
60 l water.

This mixture is mixed in the colloid mixer 1 while being simultaneously transferred by pumping via the return pipe 5, which is connected with the output of the colloid mixer 1 by way of the three-way valve 6, so that the binder slurry is discharged into the tundish 7.

In a parallel branch of the installation, water, protein-composition air entrainer and compressed air are supplied from corresponding reservoirs 12, 13, 14 via metering valves 9, 10, 11 to a conventional foam gun 8. The foam gun 8 is for instance of the type SG-E2 of the company of Würschum, Ostfildern, Germany, producing a highly fine-pored protein foam.

A first supply line 16 branches from the tundish 7 with a feed pump 15 being interconnected, and a second supply line 17 branches from the foam gun 8. These supply lines 16, 17 are united by way of a mixer tube 18 branched in the form of a Y, the connecting branch 19 of which is disposed on the side of the output; a static mixer 20 is connected with this connecting branch 19. The mixer tube 18 serves to mix the flow of binder slurry in the supply line 16 with the flow of foam in the supply line 17, the flow of binder slurry being produced by the feed pump 15 and the flow of foam by corresponding actuation of the metering valves 9, 10, 11. The porous concrete substance produced by the mixing of the two mentioned components in the mixer tube 18 is further conveyed through the static mixer 20, where a thorough homogenizing of the porous concrete substance takes place.

On the side of its output, the static mixer 20 is connected with a discharge tube 21, in which a valve 22 is inserted for the control of the discharge of the porous concrete substance.

By corresponding selection of the conveying ratio of the flow of binder slurry and the flow of foam, this porous concrete substance is adjusted such that, in its dry final state, the lightweight insulating board thus produced has a density of approximately 100 kg/m^3.

The static mixer 20 may for instance be a mixer of the type SMF-DM50/3-674.9i34 of the company of Sulzer AG, Winterthur, Switzerland. Other types of mixers may be employed as well, such as for instance the SNX-mixer of the above-mentioned company. When selecting the mixer, attention must be paid to the fact that the diameter of the static mixer is matched for the flow rates in the mixer tube. The correct design of the continuous mixer can be found by simple tests.

Molding boxes 23 can be filled with the porous concrete substance via the discharge tube 21. The molding boxes 23 serving as so-called "ripening molds" are conceived in the way of a springform, consisting of a bottom

and four displaceable side walls.

By way of a conventional traverser, the molding boxes 23 filled with the porous concrete substance are conveyed into a ripening chamber, where they dwell at approximately 50°C for 6 to 12 hours. As a result, the porous concrete substance starts to stiffen, so that the molded cake formed by the molding box 23 will subsequently be stable without the aid of the molding box 23.

In a further process line subsequent to the ripening chamber, the molding boxes 23 are removed by a special grab opening the mold, in which case all the four side walls spread apart from the sides of the initially set molded cake to a distance of about 1 cm. The side walls thus opened are lifted, moved to the side, cleaned, lubricated and again united with the mold bottoms.

The molded cake resting free on the bottom plate of the molding box 23 is transported to the cutting station in the process line. In the cutting station, a first rough blank of the molded cake is effected by oscillating wires in the vicinity of the upper and the lower side of the molded cake. When the excess cake has been removed from the upper side, the remaining molded cake has a smooth surface. As a result of the cut in the vicinity of the lower side, the molded cake or, respectively, the slabs cut from it will more readily come off the bottom plate.

Then the molded cake cut to size is further conveyed to the so-called harp, where the cake is cut into single slabs by oscillating wires. This is realized in that the wire harp moves through the standing cake from the top to the bottom.

By means of a vacuum grab the slabs are lifted off the bottom plate and placed on a hardening carriage, where they are placed at a distance of 3 to 5 mm from each other by a corresponding grab control. This distance ensures a more rapid and more uniform hardening and drying of the

boards during and after the autoclaving.

Once the hardening carriages thus occupied have been moved into an autoclave, the boards are hardened in a saturated steam atmosphere of approximately 16 bar and 220°C for a period of few hours, subsequent to which they are again removed.

The hardened boards can then again be cut to size - for instance with the aid of a band saw.

This is followed by the impregnation of the boards. To this end, a set of for instance 15 boards is placed by corresponding grabs into a dip tank, which is filled with an impregnating compound. The boards are entirely dipped into the impregnating compound. Then the dip tank is closed hermetically and acted upon by partial vacuum. As a result, the air in the open-cell structure of the boards escapes and is sucked off. When the dip tank is again vented and set to normal pressure, the impregnating compound surrounding the boards is soaked into the boards. Thus, an impregnating layer forms, proceeding from all the surfaces of the board and having an inward depth of penetration d of approximately 2 cm inward. Entire soaking of the boards is possible, too.

The impregnating compound may be a mix on the basis of modified water glass, of a hydrophobing agent and water according to the following recipe:

99 l modified water glass type 14 of the company of Wöllner GmbH of D-67065 Ludwigshafen, Germany
1 l hydrophobing agent type BS 1306 of the company of Wacker Chemie of D-80538 Munich, Germany, and
200 l water.

By alternative, the impregnating compound may also be produced on the basis of thermoset hydrophobic plastics dispersions. The corresponding

product "Vinapas" (R) of the company of Wacker Chemie of D-80538 Munich, Germany, is cited by way of example.

The impregnated boards can be dried by hot air in a drying station, in which case it must be preferred that the boards are exposed to blowing by hot air from below, the coating then drying from the underside, which prevents any sticking of the boards to the pallets on which they will be placed.

As seen in Fig. 2, a lightweight insulating board according to the invention may consist of an open-cell porous concrete body 24 of a flat, parallelepiped shape, produced in the manner described above. The porous concrete body 24 has an impregnating layer 26 extending inwards all over from its surface, for hardening and achieving a water-repellent effect. The impregnating layer has a depth of penetration d of approximately 2 cm. The impregnating compound being colored by iron oxide pigment, the impregnating layer is set off the remaining board material. Further, fiber glass 27 and so-called silicon dioxide carriers 28 are placed into the lightweight insulating boards.

THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:

1. A method for the manufacture of a porous, mineral lightweight insulating board comprising the following steps:
producing a binder slurry from cement, quartz powder, lime hydrate and water, preferably in a colloid mixer (1);
producing a foam in a foam production unit (8) from water, compressed air and an air entrainer;
mixing the binder slurry and the foam to form a porous concrete substance;
homogenizing the porous concrete substance by means of a continuous mixer (20);
discharging the porous concrete substance into a mold (23) for the formation of a molded cake for the lightweight insulating board;
initially stiffening the molded cake preferably in a ripening chamber;
cutting the molded cake into individual lightweight insulating boards; and
curing the lightweight insulating boards in an autoclave.

2. A method according to claim 1, wherein the mixing of the binder slurry and of the foam takes place by uniting a flow of binder slurry guided in first pipe (16) and a flow of foam guided in a second pipe (14) by way of a mixer tube (18) branched in the form of a Y.

3. A method according to claim 1, wherein the homogenizing of the porous concrete substance is effected by the porous concrete substance being pumped through a continuous mixer in the form of a static mixer (20).

4. A method according to claim 1, wherein the autoclaved lightweight insulating boards are provided with a water-repellent and hardening impregnation (26), which, proceeding from the surface (25) of the lightweight insulating boards extends inwards by a depth of penetration (d) of preferably at least 1.5 cm.

5. A method according to claim 4, wherein the impregnating compound is placed into the lightweight insulating board by means of overpressure or partial vacuum.

6. A method according to claim 5, wherein, for partial vacuum impregnating, the lightweight insulating board is placed into a dip tank filled with a fluid impregnating compound and disposed in a pressure-sealed vessel, and wherein the vessel is acted upon by partial vacuum to remove the air from the pores of the board and is then again vented to place the impregnating compound into the lightweight insulating board.

7. A method according to claim 4, wherein after the impregnation, the boards are dried by means of hot air.

8. A method according to claim 1, wherein silicon dioxide carriers (28) are additionally mixed into the binder slurry.

9. A method according to claim 1, wherein fiber glass (27) is additionally mixed into the binder slurry.

10. A porous, mineral lightweight insulating board consisting of a hydraulically cured porous concrete of cement, quartz powder, lime hydrate and water on the one hand and foam on the other, wherein at least the zones adjacent to surface (25) of the lightweight insulating board are provided with a hydrophobic and hardening impregnation (26).

11. A lightweight insulating board according to claim 10, wherein the impregnation (26) covers a depth of penetration (d) of at least 1.5 cm.

12. A lightweight insulating board according to claim 10, wherein an impregnating compound forming the impregnation (26) consists of water glass, a dispersion, a cross-linking agent, water and a hydrophobing agent.

13. A lightweight insulating board according to claim 12, wherein the impregnating compound is pigmented.

14. A lightweight insulating board according to claim 10, wherein the lightweight insulating board has a density of maximally 150 kg/m^3 and a coefficient of thermal conduction of maximally 0.05.

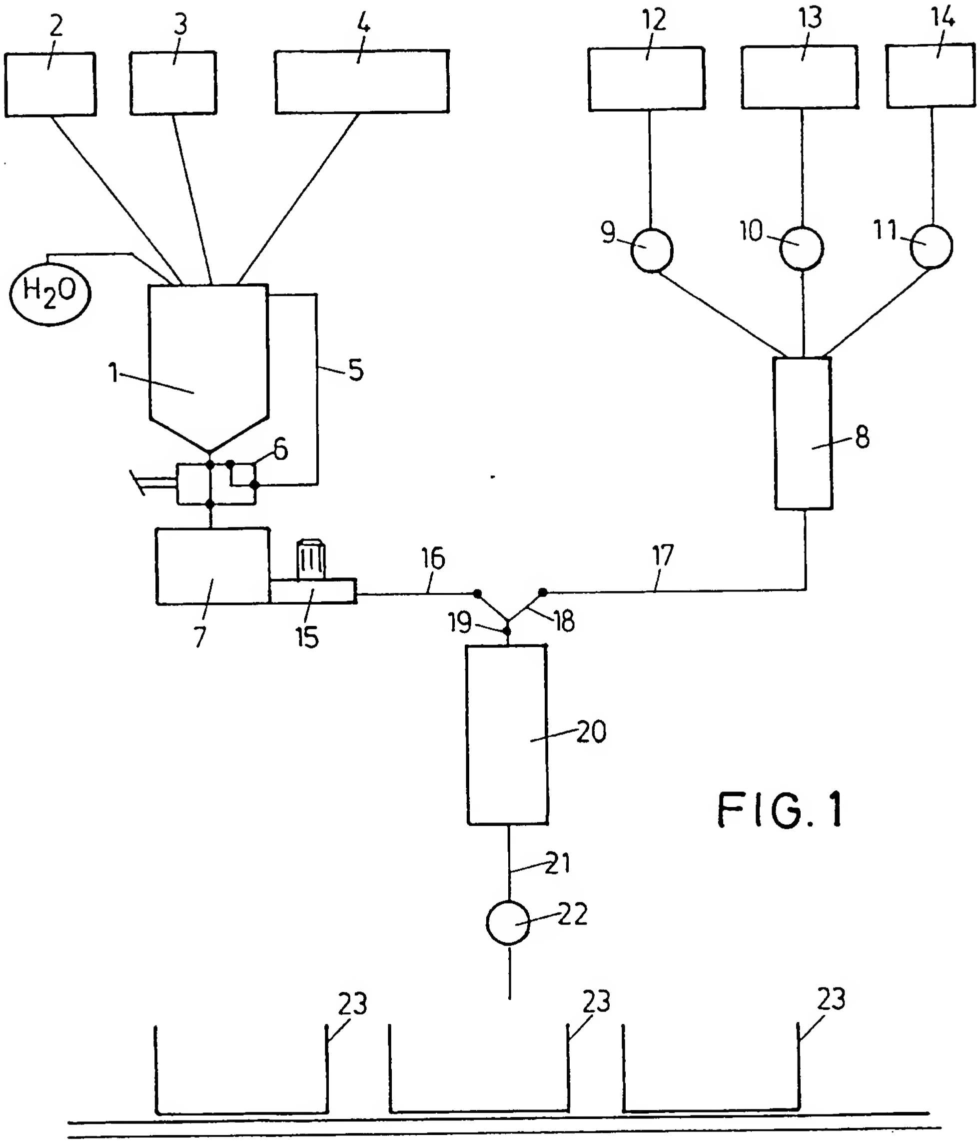

FIG. 1

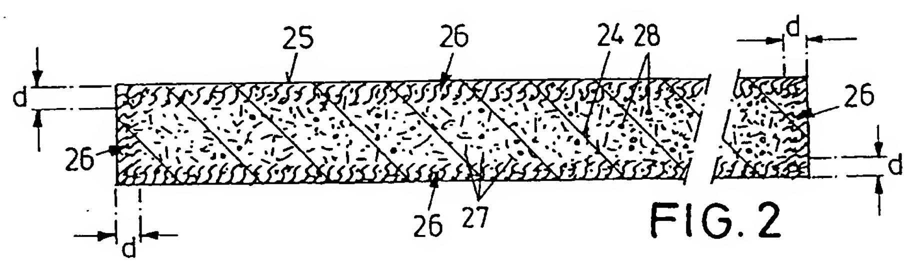

FIG. 2

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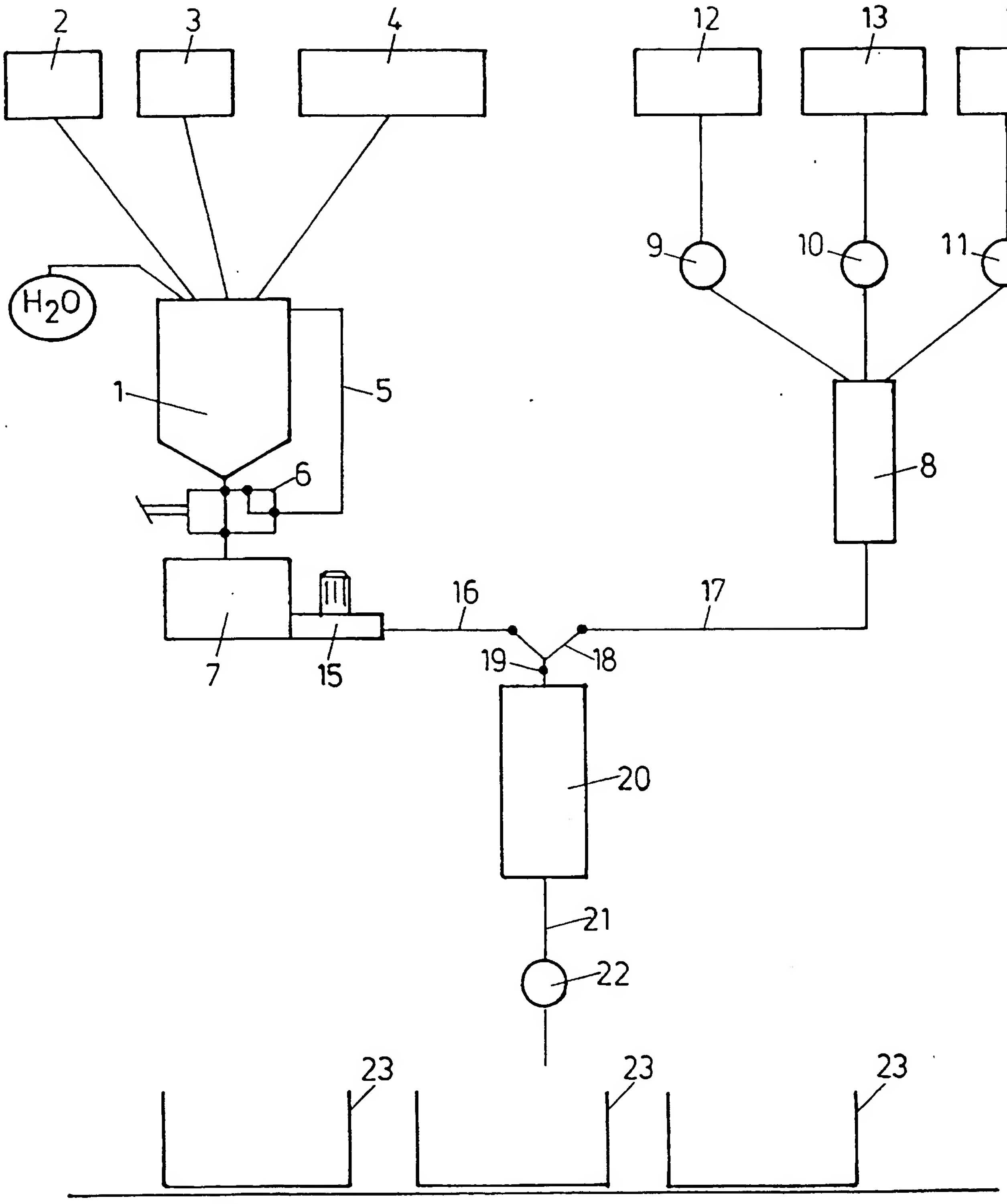
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